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OSOBENNOSTI PITANIYA I PISHCHEVYE VZAIMOOTNOSHENIYA MOLODI LOSSOSEI V PRIBREZHNYKH VODAKH OSTROVA ITURUP

THE PARTICULARITIES OF FEEDING AND THE TROPHIC RELATIONS OF JUVENILE SALMON IN THE COASTAL WATERS OF THE ITURUP ISLAND

By A.M. Kaev, V.M. Chupakhin, N.A. Fedotova

At the present time, following the work by R.R. Parker (1962, 1968), W.E. Ricker (1964), A.P. Shershnev (1975 a) and many others, an opinion is prevalent of the great importance for the reproduction of salmon with a short sweet-water cycle of development of the conditions under which the juvenile fish feed and grow in coastal sea waters, since they have a decisive influence on the survival of generations. Consequently, a knowledge of the biology of this period of life will greatly favor our understanding of the processes that intervene in forming the size of populations.

Researchers studying the nutrition of juvenile fish in the coastal shallows have arbitrarily isolated three types in the trophic relations of pink salmon and chum (Kaev, Chupakhin, 1986). First - feeding mostly on one, and the same for both species of salmon, group of organisms under conditions of complete fullness. Second - the prevalence in the food supply of a certain group of organisms, but different for pink salmon and chum, under conditions of complete fullness. The third type was characterized by a low degree of fullness and a sharp increase in the number of components used, the share of which in comparison with thr total mass of the food bolus was not in excess of 30%. In the first two cases, the high degree of fullness of the juvenile fish makes one assume an abundance of food organisms, which permits the species to feed simultaneously and successfully on one and the same or on different types of food.

The trophic relations of the third type probably must be considered as competitory and reflecting a dissatisfaction with the conditions of feeding. In that case, changes in the structure and volume of food boluses in juvenile fish should to a certain extent correspond to changes in the community of food organisms. The discovery and analysis of such situations will permit us to form an idea of the importance of food .... (end of sentence is missing, Tr.).

An analysis of the feeding of salmon reveals a partial discrepancy /2
between the spectra of the food bolus and the samples of zooplankton from the habitat of juvenile fish. At the second stage of feeding and growing these differences are not so pronounced. In the food boluses and in the samples of zooplankton the calanus (Calanoida) were dominant, and only in some fingerlings a transition to feeding on euphausiids (Euphausiacea) and young fishes poorly represented in zooplankton samples could be observed (Kaev, Chupakhin, 1986). On the contrary, at the estuary stage the feeding of juvenile fish is quite varied. Together with the plankton (mostly calanus), the young fishes fed actively on epibenthos (Harpacticoidae, Amphipoda and Decapoda) and benthos (Polychaeta) forms, as well as on air insects Insecta image (Kaev, Chupakhin, 1982), which can barely or not at all be caught with the Dzhedi net during the tradition "section" of a vertical column of water (Tab. 1). Researchers were facing similar problems when studying, in particular, the feeding of pink salmon and chum fingerlings in the coastal shallows of Puget Sound, British Columbia. V. Kaczynski and coauthors (1973) used a pump with the help of which they succeeded in collecting demersal organisms found directly in the stomachs of fishes.

Another problem is apparently the inadequate quantitative reflection by zooplankton samples of the actual agglomeration of animals in the area under study. This becomes obvious when one is comparing data on the composition of zooplankton and the feeding of fish (Tab. 2). Thus, on June 29, 1986 in the little bay near the Saratovka River, in addition to the calanus - the only group having a concentration of 80.6 mg/m^3 - the young fishes fed actively also on organisms not recorded in the food sample - mysids (Mysi- /3
dacea), gammarids (Gammaridae) and fish larvae (Pisces larvae). On the con-

trary, on June 28 in the Kitovaya Bay the fingerlings fed mainly on calanus when their biomass was relatively low - 24.2 mg/m^3. Moreover, during the preparation of this sample of zooplankton it became clear that 53% of the biomass belonged to organisms having a body weight of less than 0.1 mg, i.e. organisms rarely found in the stomachs, certainly not in chum (Kaev, 1983). The remaining organisms are represented by Eucalanus bungii with a concentration of 5 specimens per cubic meter, which in any approximation can not correspond to the average of 6-7 eaten by each one of many thousand fingerlings that were feeding in the bay. Consequently, either the calanus were eaten in mass with the competition being high or the zooplankton sample did not reflect their actual concentration in the bay. The former supposition is contradicted by all the data on the fullness of fingerlings and the limited utilization - when the main food was scarse - of other food sources, for instance harpacticides present in the zooplankton sample but avoided by the juvenile fishes.

An alternative to the first supposition was supplied also by the results of horizontal test trawling with the Dzhedi net that was introduced in the coastal shallows in 1986. First of all, the test revealed compact agglomerations of harpacticides and gammarids, as well as of comparatively large and fast-moving adult mysids and young fishes of other species than salmon. Secondly, the varying quality of the catches is proof of pronounced dynamics in time and of heterogeneity in the spatial distribution of animals in the shallows. In totality, they are responsible for the considerable fluctuations in their biomass (with the exception of calanus which are less typical of the litteral zone) as compared with the open waters of the gulfs (Tab 3). Thirdly, the collected samples contained animals usually found in the stomachs of salmon (see Tab. 1). A discrepancy in the above list may be noted only with reference to the group of polychaetes, since they are represented in the samples of zooplankton, /4 with rare exceptions, by plankton larvae having a body mass less than 0.05 mg, and in the stomachs by demersal forms with a body mass in some specimens of up to 10 mg.

An intense fluctuation of the biomasses of groups of animals in the layers of water is obserable in the course of the day as well (Fig.).

To facilitate the presentation, in view of the considerable difference in the values of biomasses of various groups of organisms, the calanus and the gammarids are shown in the graph magnified ten times. With regard to the two day-long surveys conducted in different years, one may note the general tendency of the most abundant catches to be made during the evening and night, which may be explained perhaps by the fact that demersal forms, especially harpacticides, rise to the higher strata of water during darkness. At the same time, we observed in 1987 also an unexpected increase in the catch of epibenthos forms during daylight, which coincided with the beginning of full ebb. The result was duplicated by taking samples at the start of ebb, the lowest level and at rising water during spring tide (see Fig., June 15), the abundance of harpacticides in the layers of water being recorded at 2:00 P.M. at the moment of full ebb. Obviously, these scanty data do not adequately answer the question of the genesis of daily fluctuations in the biomasses of groups of animals in the coastal shallows, but they stress the need for a detailed study of the problem. This is also important because the trophic activity of juvenile fish apparently is affected by the high and low tides. If in 1986 the generally expected data on the evening and night feeding of juvenile fish were obtained (Shershnev, 1975 b, Karpenko,1982, Godin, 1981), in 1987 with a relatively high water level that continued to rise, the evening peak in the trophic activity of juvenile fish was not at all apparent, but the fullness of juvenile fish abruptly increased at noon during full ebb (the figure shows data for chum, the changes in which are synchronous with those for pink salmon). Just like in the case of the dynamics of the biomasses of food organisms, this process was duplicated on June 15 and produced a similar result. /5

An analysis (see Tab 1) of the average composition of the samples of food organisms taken at various times and of the food boluses extracted from juvenile salmon confirms the conclusion arrived at earlier (Kaev, Chupakhin, 1982; Kaev, 1983) of the existence of a trophic divergence in pink salmon and chum at the intraspecific and interspecific levels. It is noteworthy that samples of zooplankton obtained by horizontal trawling correspond better to the food boluses of juvenile fish not only in the

spectrum but also in the amount of individual components. Thus, relative and absolute values for the calanus biomasses obtained during vertical trawling in the shallows in 1986 and 1987 were similar. However, in 1987 their amount diminished noticeably even in the stomachs of pink salmon, where they usually make up the bulk of the food bolus. But this diminishment is in complete agreement with the weak representation of calanus in the community of food organisms in 1987 revealed during horizontal trawling with the Dzhedi net at the very places where juvenile fish samples were taken (see Tab. 1) and in the broader probing of the littoral zone. First of all, attention must be paid to the differences during the years under study in the biomasses and participation in the community of calanus and gammarids - the former usually being more common in the stomachs of pink salmon, the latter in the stomachs of chum (Bakshtanskii, Nilova, 1965; Karpenko, 1981; Kaev, Chupakhin, 1982). In compact agglomerations of these forms, the young fish, excepted some small pink salmon, avoided almost completely the harpacticides as comparatively minute organisms, nor did they hunt for the fast-moving and comparatively large (about 25 mg on the average) young specimens of other fish species. The mysids having a body weight of 10-35 mg served as occasional food. /6
The pink salmon fed selectively on calanus, the chum salmon on gammarids. Moreover, the chum fed actively on polychaetes, but the index of selection in this case has been replaced by "+", since in the zooplankton samples they are represented only by plankton larvae (see above). In 1987, with low biomasses of the usual components of food, the juvenile fish also selectively fed on their "favorite" calanus (pink salmon) and gammarids (chum), but at the same time, together with the comparatively large mysids and young fishes, they consumed minute organisms - harpacticides - on a large scale.

Thus, we are faced with a broader spectrum of foods (in the sense of an increased number of leading organisms, and not simply at the expense of accidental consumption of various organisms) when the "favorite" food is no longer abundant. An active consumption of harpacticides, especially by larger fingerlings, is rather an act of necessity. The data on the composition of the food boluses (see Tab. 1 and 4) give the impression that the differences in the feeding of juvenile fish of various size groups depend

on the selection of food objects mostly according to their size. In this connection we shall discuss in greater detail the problem of chum salmon by dividing the consumed organisms into groups according to their body weight (Tab. 5). The analysis definitely shows that the growing fingerlings start feeding on larger objects even within the limits of individual groups of animals.

We shall take the example of chum and analyze in more detail - structuring the consumers and their victims according to size - the feeding in a critical situation, when the comparatively large fingerlings were feeding on harpacticides. The group of harpacticides has not been set apart, since it was included in its titality into the class of organisms having a body weight from 0.1 to 1 mg (Tab. 7), making up in this class 78% of the biomass of copepods in the zooplankton sample and 99-100% in the stomachs of chum. As a result, we are faced with a mechanism of trophic inversion close to the one described for the juvenile fish in the coastal shallows. It is noteworthy that the results obtained in the study of a natural population of chum agree well with .... (words missing in the text, Tr.) in aquariums: fishes measuring 37-44mm in length /7
were observed to choose food organisms (Calanus) measuring 1.6-4.5 mm in length and to display a negative reaction to small-sized food objects - less than 1.5 mm (Le Brasseur, 1969).

Under conditions of sufficient food supply, extreme variants of almost complete coincidence or complete discrepancy in the feeding spectra of the juvenile fishes of different species are possible. Even large fingerlings feed on mass forms, avoiding searching out and catching large and fast-moving organisms (see Tab. 4 - 1986). One gets the impression that under the conditions of coastal shallows the "favorite" food" for both species of salmon still are the Calanidae. Firstly, cases of almost complete coincidence of the feeding spectra were connected with this group of organisms. Secondly, in 1987 we noticed a wide-ranging switch of different-sized juvenile chum (34-52 mm) to feeding on Calanidae after they appeared in mass in the shallows. But in any situation, the range of selection of main food components is usually wider in chum than in pink salmon (Kaev, Chupakhin, 1986), which under conditions of abundant food supply may be considered as a manifestation of the mechanism of interspecific adaptation in anticipation of a possible deterioration of the food situation. In the

concrete unfolding of such a process, the mutual relations between the fishes at some point become antagonistic. At the intraspecific level this is manifest in the unequal ability of different-sized fishes to catch "attractive" food. It is interesting that two groups of chum sharply differing from each other in size revealed a similar characteristic in their selection of food objects: in both cases, minute forms were fed on mostly by small fingerlings. But at the same time, in the group of larger juvenile fishes (see Tab. 7) small forms (mainly harpacticides) were consumed by specimens measuring less than 60 mm in length, which made possible in the group of small fishes (see Tab. 5) the inclusion into the category of large ones of specimens measuring more than 45 mm and the selection of mostly large food organisms. The mechanism is probably connected with an increase in the distance of reaction to the victim in larger fishes, as was experimentally shown with the Arctic grayling Thymallus arcticus (Schmidt, O'Brien, 1982. /8

The obtained results of the evaluation of feeding and food supply of juvenile salmon during the early marine period of life permit us to continue this work at the level of monitoring. Not detracting from the advantages of the "energetic" approach to the problem of correlations in the ecosystem, at the origin of which was G.G. Vinberg (1956), we are in complete agreement with M.V. Zheltenkova and A.V. Kogan (1985) about the priority of studies on the feeding characteristics and trophic relations in all their variety, i.e. by taking into account the populations' mechanisms of adapting to the environment. Moreover, this paper has left aside the problem of the formation of plankton communities in the dynamically active zone of the Kuril coastal shallows which, together with the selectivity of fishing gear and heterogeneity in the distribution of organisms seriously hampers a realistic absolute evaluation of food supply for the juvenile fishes and their dynamics. Further collection of data and the interpretaion we propose will make it possible, we hope, to determine the frequency and the conditions under which critical situations appear during the feeding and growing period of juvenile salmon. It will also permit us to develop criteria for their evaluation indispensable to the theory of formaton of the size of pink salmon and chum populations in the early marine period of life.

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